Table 2. Seven Categories of Threats and Drivers for Puget Sound Ecosystems Table Note: Threat/Driver categories were identified by the NOAA Threat/Driver Steering Committee, in support of the Threat/Driver DPSIR Demonstration Project (2008), and in conjunction with the forthcoming NOAA Integrated ecosystem assessment

Threat/Driver Category	Threat/Driver Attributes (specific threat types)	Examples of Impacts to Ecosystem Outcomes
Natural and external drivers	**Natural drivers** Earthquakes, tsunamis, vulcanism, landslides, storms, floods, wildfires, naturally occurring hypoxia, natural variation and changes in rainfall, snowmelt, air temperature **External Drivers** 1. Human population growth: increasing numbers of people in the region amplify the impacts of all other threats, both existing and future, to Puget Sound ecosystems 2. Climate change: A changing global and Pacific Northwest climate interacts with the effects of human drivers and threats to Puget Sound ecosystems. Increased temperatures, changes in volume and timing of precipitation and stream flows, as well as a reduction in snowpack will have major implications for the region's water resources, ecosystem health, forests, fish and wildlife resources, and agricultural practices. A rise in sea level is likely and some portions of the Puget Sound nearshore and marine environments may experience increases in coastal erosion, landslides, inundation and flooding.	• Episodic, dynamic natural disturbance regimes contribute to functioning natural systems • Episodic, dynamic, natural disturbance regimes can threaten public safety, interrupt local/regional economies, destroy property, and threaten infrastructure • Human population growth and climate change can amplify the impacts associated with some threats to ecosystem health identified within this summary table
Habitat alterations	**Marine Habitat Alteration Types** • Overwater structures • Marinas • Dredging and dredging disposal • Breakwaters, groins • Boat wakes and prop wash • Aquaculture • Marine hydropower • Marine wastewater discharge	▪ Salmon recovery, Orca Recovery, and other mandated species recovery ▪ Altered habitats may not support functioning ecosystems which in turn are not able to provide critically important ecosystem services to society ▪ Altered habitat forming processes, such as the disconnection of rivers with their floodplains, translates to diminished quantity and quality of habitat for a variety of terrestrial and aquatic species ▪ Altered habitats do not support complex food webs, thereby reduce biodiversity and threaten the survival of some species ▪ Altered habitats do not regulate storm water as effectively as intact landscapes ▪ Altered habitats decrease aesthetic and scenic resources, recreational

Threat/Driver Category	Threat/Driver Attributes (specific threat types)	Examples of Impacts to Ecosystem Outcomes
	• Roads and transportation infrastructure • Derelict Gear **Shoreline Habitat Alteration Types** • Armoring • River levees • Native vegetation removal • Boat launches and recreation facilities • Residential, commercial and industrial development • Mineral/gravel mining • Roads and transportation infrastructure • Impervious surfaces **Freshwater Habitat Alteration Types: in-water resources** • Dams, culverts, locks, other flow regulating structures • Overwater structures • Marinas • Dredging and dredging disposal • Breakwaters, groiins • Boat wakes and prop wash • Aquaculture • Marine hydropower • Vessel discharge • Roads and transportation infrastructure • Derelict Gear **Terrestrial Habitat Alteration Types** • Timber harvest • Agriculture and livestock grazing • Filling of depressional wetlands • Impervious surfaces • Roads and transportation infrastructure • Mineral/gravel mining • Residential, commercial and industrial development	opportunities, and other qualities unique to the Pacific Northwest region ▪ Altered habitats can provide some protection of property from natural disturbances, places where people live, work, and travel; and energy for human uses.

Threat/Driver Category	Threat/Driver Attributes (specific threat types)	Examples of Impacts to Ecosystem Outcomes
Freshwater resources (surface and groundwater)	**Surface Water Resources** • Water withdrawals and diversions; water demand projections associated with future domestic, municipal, commercial, and industrial water uses • Altered hydrology, including loss of wetlands and floodplains • Alteration of stream flows and channels, including ditching, armoring, levee construction, and dams • Decreases in groundwater recharge • Increases in peak stormwater flows • Decreases in baseflows (sustained low flows) **Groundwater Resources** • Depletion of aquifers and groundwater resources • Seawater intrusion into groundwater resources	• Current water supply in some watersheds is insufficient to support current and future projected societal needs • Current instream flows do not support some aquatic species and ecosystems • Seawater intrusion threatens current/future access to freshwater resources in marine/nearshore environments • Groundwater recharge is insufficient in some areas to meet current and future projected needs for humans and wildlife • Altered habitat forming processes, such as the disconnection of rivers with their floodplains, translates to diminished quantity and quality of habitat for a variety of terrestrial and aquatic species
Pollution (water, air, soil)	**Water Pollution** ▪ Loading and runoff from developed (e.g., roadways, parking lots) or undeveloped (e.g., agricultural, forested) lands into surface waters ▪ Stormwater or wastewater spills/discharges ▪ Discharge from boats ▪ Toxics or oil spills/discharges ▪ Groundwater discharges of pollutants to surface waters ▪ Malfunctioning septic systems ▪ Combined sewer overflows ▪ Wastewater discharges **Air Pollution** • Vehicle use, machinery, and burning of fuel for a variety of uses • Air-born, fine pollutant particles from agricultural fields, industrial and construction sites, and other land surfaces • Atmospheric deposition of pollutants directly to the marine water surface of Puget Sound	• Food sources are sometimes contaminated – toxics, biotoxins, and pathogens in fish, shellfish and other biota • Beach closures reduce availability of shoreline dependent recreational opportunities • Toxic air emissions and deposition can be a risk to human health • Current surface water quality conditions impair some aquatic species and ecosystems (e.g., low dissolved oxygen and associated fish kills) • Area-wide toxics are found in soils, sediment, and dust and pose risks to human health • Hazardous waste sites contain contaminated soils and sediments that can pose risks to fish and wildlife viability and human health

Threat/Driver Category	Threat/Driver Attributes (specific threat types)	Examples of Impacts to Ecosystem Outcomes
	Soil Contaminants • Commercial, industrial, livestock, and other land uses which contribute contaminants to soil resources	
Artificial propagation	• Aquaculture practices such as salt water net pens and ponds, fish hatcheries and off-site releases of hatchery fish • Shellfish aquaculture • Species culture for agricultural forestry	• Cultured salmon and steelhead from hatcheries can be a risk to threatened wild salmon and steelhead in Puget Sound, through both genetic and ecological mechanisms. • Private aquaculture net pens that rear fish year-around, may pose threats to Puget Sound through fish feces, uneaten feeds, accumulated heavy metals in sediments, and the impact of pharmaceuticals and pesticides on non-target organisms. • Shellfish aquaculture methods modify condition of beaches and the lower intertidal zone. Impacts on populations or the ecosystem have not been well studied. • Species culture, from agricultural forestry to aquaculture, may contribute pollutants to the environment and facilitate the introduction of invasive species. • Many species grown for aquaculture in Puget Sound are non-native species, such as Manila clams, Mediterranean mussels, Pacific oysters, and Atlantic salmon. • Several artificial propagation programs are designed to help in rebuilding at-risk populations: the Olympia oyster, White River Spring Chinook, South Fork Nooksack, North and South Fork Stilliguamish chinook, and Hood Canal Summer chum,are a few examples.
Harvest	**Fishing**: freshwater fisheries and marine fisheries, including bottom trawling, longline, set net, pot- and spear-fishing, gillnet, purse seine, angling **Shellfish Gathering**: freshwater mussels and marine collection of shellfish **Logging:** harvest of timber (see habitat alteration) **Hunting**: over-harvest of sensitive species; disruption of natural behavior	• Over-harvest is a threat to rockfish, Pacific hake, and pinto abalone, for example. • Harvest management can increase human well-being of fishers and consumers, and has led to a decrease in the overall harvest mortality of wild Chinook salmon, and could be used to prevent over-harvest of many species, such as halibut, geoduck, sea urchins, sea cucumbers, and other invertebrates. • Harvest may have food web impacts, as predators experience declines in important prey. • Harvest may indirectly impact non-target species such as other fish, birds, and porpoises that are unintentionally captured. • Derelict fishing gear, such as nets, pots or traps, pose a threat to invertebrates, fish, marine mammals and birds in Puget Sound.

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Invasive species	• Imported seeds, fruits, plants, and vegetables • Ballast water discharges from ships • Imported soil, especially from nursery stock • Commercial and recreational boat hulls • Travelers' clothes and shoes, cars, and airplanes • Solid waste and soil dumped as fill in wetlands • Exotic pets and plants that are released "into the wild" • Accidental releases from aquaculture practices	• Purple loosestrife, *Spartina* spp., *Sargassum muticum*, knotweed, Scotch broom, and other invasive species threaten native ecosystems and species. • *Spartina* has been shown to be transforming estuarine intertidal habitats. • Studies demonstrate a link between domestic animals (including feral cats and rodents), freshwater runoff, and transmission of the potentially fatal disease *Toxoplasma gondii* to river otters in the San Juan Islands. • Invasive species are a threat to more than a quarter of the plant species in Washington that are of conservation concern.